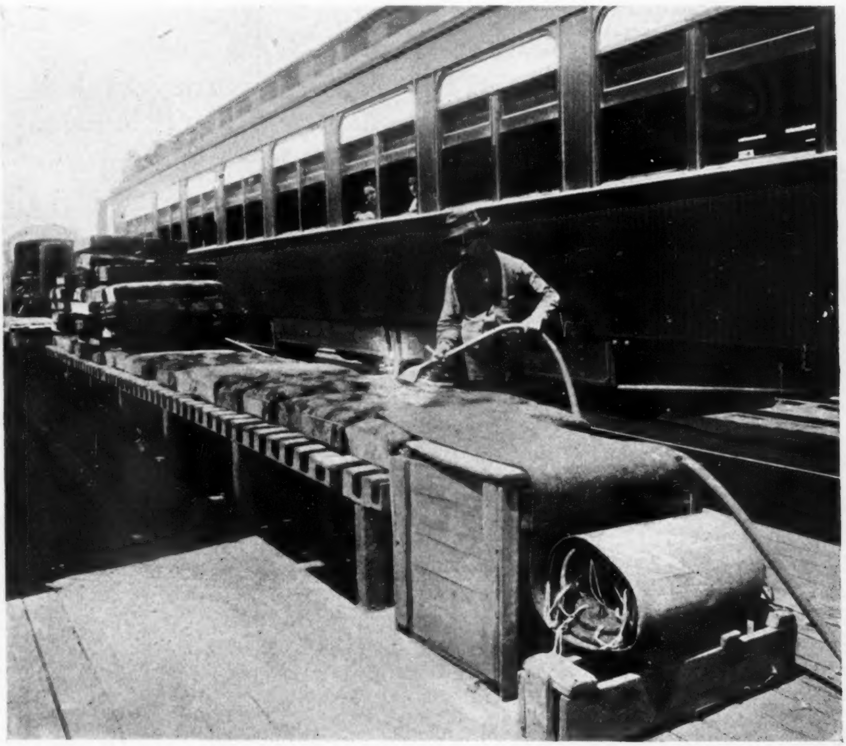
Compressed Air

DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR·

VOL. I. NEW YORK, JUNE, 1896. No. 4



CLEANING CAR CUSHIONS AND CARPETS WITH COMPRESSED AIR, AT THE PULLMAN PLATFORM NEW JERSEY CENTRAL RAILROAD YARD, JERSEY CITY, N. J.

Compressed Air

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - - Editor and Publisher
A. E. KENNEY, - - - - Managing Editor
A. NEWTON, }
J. E. QUINTERO, } - - - - - Associates

Subscription: including postage, United States, Canada and Mexico $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

London Office, 114a Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

VOL. I. JUNE, 1896. NO. 4.

IT is a common thing when compressed air is treated by the secular press, to read about the marvelous things that may be accomplished by this power. It is sometimes claimed that compressed air power will be revolutionary in its effect, when, as a matter of fact, being now the servant of steam, air only claims its place as a useful power, doing good work because of its capacity for long distance transmission, its availability, freedom from danger and its adaptability to so many different purposes.

IT is to be regretted that the newspapers should have gone so far in their statements in respect to the application of compressed air for street car work in New York City. This subject is one for engineers, inventors and financial men, and not for newspaper reporters, as the application of compressed air for this purpose, is still more or less in the experimental stage. There is not in America at this date a single line of cars run regularly by compressed air motors, though, as pointed out in our last issue it is simply a question of adaptability and experience, as air power has been successfully applied to locomotives and other traction engines.

AMONG the notes descriptive of the recent St. Louis tornado is the following:

Perhaps the most impressive evidence of the storm's force is shown in the wrench given to the eastern end of the Eads bridge. There the tornado dealt with stone masonry. It tore off and tumbled down tons upon tons of this masonry. Beginning with the big eastern pier and extending to the foot of the incline, the tornado cut off the upper part of the structure as if it had been of flimsy trestle work.

What power is this which is exhibited with such marvelous intensity? Some have claimed that the destructive force of a tornado is electrical, but this claim can scarcely be sustained by the facts. The power of air exerted in this mysterious manner indicates that there is something unknown in this line which has not yet been properly defined.

Cleaning car cushions and carpets and other furnishings, brings to the mind the possibilities that may yet be reached by the use of compressed air. A public supply once furnished, would become as indispensible as water or light. Can we hope for the time when the housewife may take down the air pipe from its little hook and apply it briskly to the carpets which have had to be "shook" heretofore, and to the rugs which have had to be "beaten," and to our clothes which used to be "whisked." The application of compressed air for domestic purposes is as yet only a dream, but the contemplation of such a condition may be classed with other yearnings for domestic bliss.

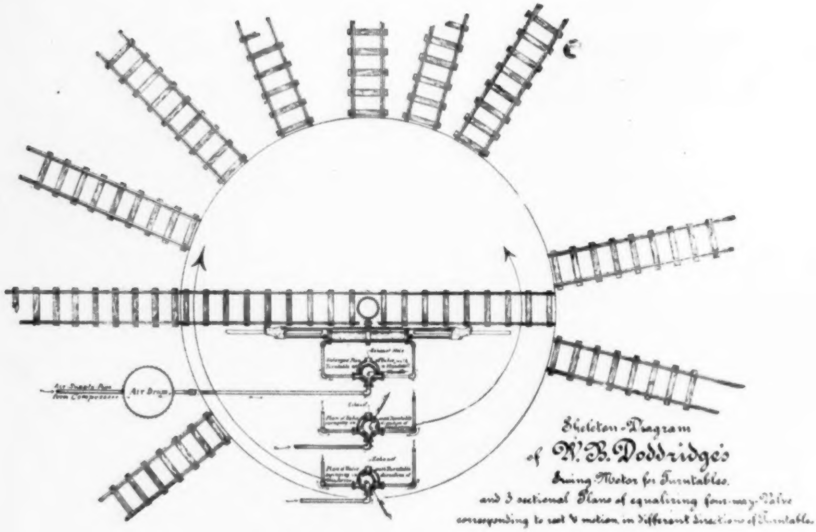


DIAGRAM SHOWING DODDRIDGE TURNTABLE.

Compressed Air Turntable.

This illustrates a compressed air turntable the invention of W, B. Doddbridge, General Manager of the Missouri Pacific Railroad, St. Louis, Mo. The diagram shows that the cylinder is located at the base of the pit and is operated by allowing the air to enter either end of the cylinder. The piston forces a rack along, thus actuating a pinion and this swings the table to the desired position.

This appliance may be used for swinging other heavy bodies and can be used for stationery derricks. The device is about to be manufactured and put on the market.

The increasing number of installations of the air lift pump shows that when Dr. Julius G. Pohle, invented and perfected this system, he confered a great and lasting benefit upon the industrial world.

It is chiefly used for increasing the supply frcm deep wells, and also is especially adapted to handling chemicals as it has no valves or moving parts.

Cleaning Car Cushions by Compressed Air.

The illustration on the cover of this issue represents another useful application of compressed air. The picture was taken at the Pullman platform in the N. J. Central yards in Jersey City, N. J. Cushions, carpets, bedding, curtains and rugs are taken from the cars and arranged conveniently on a platform, the operator takes the hose with its spray nozzle and holds it directly over the article to be cleaned, air is turned on and the accumulations of dust of one trip is instantly dissipated. It takes le than a minute to thoroughly cleanse a car cushion. Besides removing the dirt, the upholstery is purified by the vigorous airing it has received. The hose is taken inside the car and the stationery upholstery and hangings are renovated.

Few dwellings receive the refreshing application of air that these cars receive. In no other way can healthfulness and purity of atmosphere be assured in railway carriages. Its use should be extended to every railroad.

QUICK-ACTION AUTOMATIC BRAKE.

The April issue of COMPRESSED AIR contained a brief resume of the history of the air-brake down to the completion of the present quick-action automatic brake, which has successfully stood the test of time and use and demonstrated beyond peradventure its superiority over all other brakes known and tried.

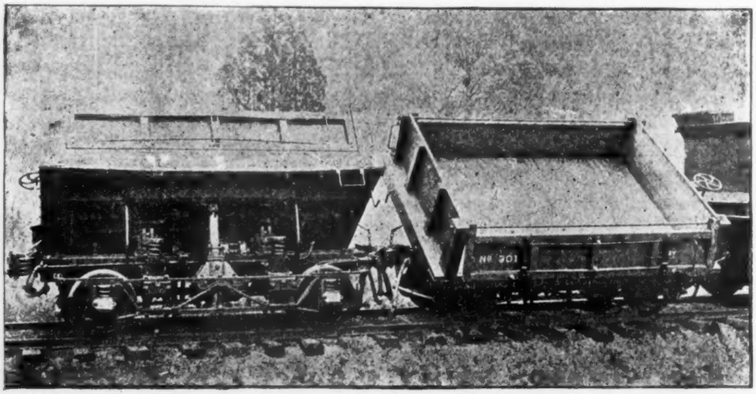
In the quick-action automatic brake the application of the brakes to the wheels is effected by reducing or cutting off the air pressure in the main train pipe leading from the main air reservoir. This reservoir is carried beneath the engine and is charged with air from a pump also on the engine, the pump being operated by steam from the boiler. The "engineer's brake and equalizing discharge valve" is located in the cab of the engine and is connected to a pipe leading from the main reservoir and a second pipe communicating with the train-pipe. This valve regulates the flow of air from the main reservoir into the train pipe for releasing the brakes, and from the main train or brake pipe to the atmosphere for applying the brakes. The main train pipe leads beneath all the cars of a train, being connected between the cars by flexible hose coupled to the pipe sections. By means of an angle-cock at each end of the pipe of each car, such pipe is closed before separating the couplings, thus preventing the escape of air and the application of the brakes when the cars are uncoupled.

Beneath each car is an auxiliary reservoir which takes a supply of air from the main reservoir, through the train pipe, and stores it for use on its own car. The brake cylinder is connected to this auxiliary reservoir, and its piston rod is attached to the brake levers in such a manner that, when the piston is forced out by the air pressure, the brakes are applied. The quick-action automatic triple valve is connected to the main train pipe, auxiliary reservoir and brake cylinder, and is operated by the variation of pressure in the pipe—first, so as to admit air from the auxiliary reservoir to the brake cylinder, which applies the brakes, at the same time cutting off communication from the brake pipe to the auxiliary reservoir, or, second; to restore the supply from the train pipe to the auxiliary reservoir, at the same time letting the air in the brake cylinder escape, which releases the brakes. A pump-governor regulates the supply of steam to the pump, stopping it when the maximum air pressure desired has been accumulated in the train pipe and reservoir.

In practice, a moderate reduction of air pressure in the train pipe causes the greater pressure remaining stored in the auxiliary reservoir of each car to force the piston of the triple-valve and its slide-valve to a position which will allow the air in the auxiliary reservoir to pass directly into the brake cylinder and apply the brakes. In the event of emergency or accident, a sudden reduction will be had in the train-pipe, producing the same effect, and in addition to this, causes supplemental valves in the triple-valve to be opened, permitting the pressure in the train pipe to also enter the brake cylinders, increasing the pressure from the auxiliary reservoir about 20 per cent., resulting in instantaneous action of the brakes to their highest efficiency throughont the entire train. Hence, in case of accident, real or threatened, a train can be brought to an immediate stop. When the pressure in the train pipe is again restored to an amount in excess of that remaining in the auxiliary reservoir, the piston and slide valve are forced in the opposite direction, opening communication from the train pipe to the auxiliary reservoir, and permitting the air in the brake cylinder to escape to the atmosphere, thus releasing the brakes. When the engineer wishes to apply the brakes he operates the "engineer's brake valve," so as to close

one port, retaining the pressure in the main reservoir, and then permits a portion of the air in the train pipe to escape, reducing the pressure therein and allowing the greater pressure in the auxiliary reservoirs to be brought into action on the brakes through the agency of the triple valve. To release the brakes he so turns the valve as to allow the air in the main reservoir to flow freely into the train pipe, restoring the pressure therein to a degree greater than that in the auxiliary reservoirs.

A valve in each car, called the "conductor's valve," is capable of operation by any of the train men in the event of emergency. By pulling on the cord of this valve the latter will be opened and allow the air in the train pipe to escape. Should any of the cars of a train become accidentally disconnected, the air in the train pipe escapes and the brakes are instantaneously applied in each section of the train. They are likewise applied in the event of a pipe bursting. Hence, the underlying principle is that any reduction of pressure in the train pipe applies the brakes to the wheels.



Cars Dumped by Air.

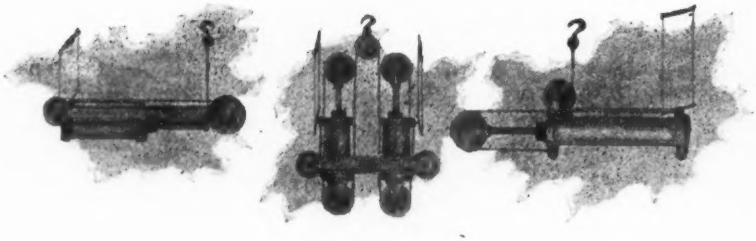
The Thacher Compressed Air Dumping Car is being placed on the market by the Thacher Car and Construction Co., New York. It is claimed that with this car much time is saved, and that loads can be discharged by trainmen of the construction train, the engineer operating it from the engine, and the ordinary air pump supplying the air.

The mode of operation of the dumping device is as follows:

The body of the car being pivoted centrally will dump to either side, or to one side only, according to its construction.

This is done by means of a cylinder mounted on the truck frame, the piston of which is coupled directly to the car body; another smaller cylinder called the "latch cylinder," fitted with piston rod and slide valve, positively and automatically operates the latches which lock the car body in its horizontal or normal position, and also regulates the distribution of the air to the large or dumping cylinder as required, moving its piston up and down, thus dumping the body and returning it again to its horizontal position.

An independent reservoir which each car carries contains an ample supply of air for the purpose of supplying the movements of the dumping cylinder, and is filled and kept at the necessary pressure by the engineer at any convenient time, a check valve preventing its escape until needed. This reservoir is filled by the regular train pipe, which is also utilized as the air brake pipe, does and not interfere with the latter's action.



Compressed Air in the Foundry.

PAPER READ AT THE FOUNDRYMEN'S CONVENTION, HELD IN PHILADELPHIA, MAY 12, 1896, BY CURTIS W. SHIELDS.

Compressed air has long been known as an ideal medium for power transmission, but its introduction into the arts has been slow, because of the general lack of knowledge of the subject, due in a measure to the limited experience had with it.

It has been looked upon as being an expensive power at best—too much of a mystery and something to be avoided rather than encountered and mastered.

In many cases cheap and badly designed air compressors are put in use, and where such machines have been designed to occupy a small space or to be light in weight, compressed air is sure to cost a great deal to produce, and this has stood in the way of the general introduction of compressed air more than anything else.

Only recently inventive genius has been turned toward the development of labor-saving machines which would use compressed air as a motive power.

Since compressed air is now produced economically, owing to the many recent improvements made in the design and construction of compressing machinery, the up-to-date plant without its air compressor in the power house is the exception. Devices for using air are being placed upon the market in rapid succession, and its field of usefulness has broadened until now it is practically indispensable in a great many operations, and its economic value is recognized.

Under the ordinary conditions existing in foundries a belt-driven compressor is usually more favorably considered than one driven by steam.

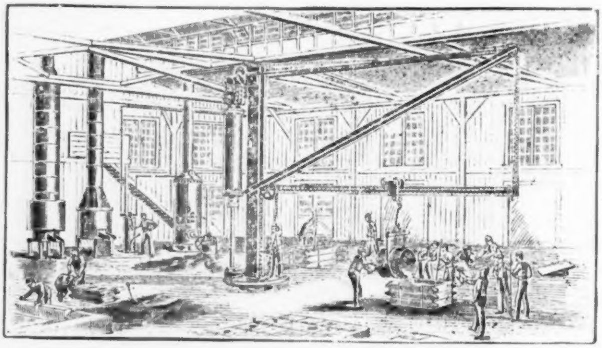
The ordinary shop engine of a good type gives better results for the amount of steam used than if the steam was used to drive a small compressor direct.

A belt compressor fitted with a proper regulator absorbs only enough power to meet the demands of the work performed, and being run in connection with other machinery, its effect on the coal consumption is not noticeable.

However, in many cases a steam-driven compressor is preferable, because a high class steam-actuated compressor uses steam almost if not quite as economically as a shop engine, and whatever loss there may be is more than made up for by the advantages of a steam-driven compressor. With them all shafting and belting are avoided, and the machine can be located in the engine room, where it can be under the care of the engineer. If installed in the foundry the dust and sand have a very appreciable effect upon the bearings and moving parts, and no matter how carefully housed,

your compressor cannot be as well taken care of as though it were in the engine room. Frequently, when a foundry has no steam power, the compressor can be located in a neighbor's engine room, and power rented to operate it, as the air pipe can be run any desired distance quite readily and at small expense.

Transmission of power by compressed air has the advantages of certainty and regularity in action; simplicity in machinery, freedom from the possibility of fatal accidents, and the assistance given to ventilation and in cooling the shop—these last being considerations of much importance in many cases. Works employing this method do not require the supervision of a specially qualified expert, and the chances of interruption by accident through negligence are certainly less than in any other form of power transmission.



When we come to the question of laying out the piping for a foundry, it is well to keep this simple rule in mind. The head necessary to drive the air through the pipe is as the square of the velocity, and to obtain the best results the flow of air through the pipe should not exceed 20 ft. per second. If this is borne in mind, air can be conveyed almost any distance with little or no loss.

The receiver should be placed in any convenient place, and should be of not less capacity than the rating of the compressor in cubic ft. of free air per minute.

It is preferable to have the inlet pipe from the compressor enter the receiver near the top and the outlet near the bottom, and at right angles to the inlet. A drain cock at the lowest point should be provided, and a pressure gauge safety valve on the top is a great convenience.

Too frequently no attention is given to leaks in the air pipes, as the air is not visible and causes no discomfort in its escape. Leaks, however small, should receive prompt attention if anything like economical results are desired.

Leaks in air pipes are fortunately easy to find, because of the hissing noise caused by the escaping air. This point is an important one in comparing pneumatic with electric transmission of power.

Leaks in electric wires are hard to discover, and are usually found after some damage has been done. The current may be led away through the crossing of other wires, moisture, or frame of building if of iron, and occasions an unseen, though none the less undesirable, loss.

A little thought and attention given to the elimination of turns and angles in the pipe mains will amply repay for the trouble. It is a great economy to lead the air mains centrally and then run smaller connections to points adjacent and conve-

nient to place air is to be used.

If this is done, short lengths of hose pipe can be attached wherever most convenient for connection to hoists, sand-sifter, or other apparatus, or the air can be used for the same purposes that the bellows and brush are employed.

The application of the air hoist to cranes may be made in an almost endless variety of ways to meet the requirements of foundries. The most common types are simple cylinder hoists either vertical or horizontal, or in combination with a low pressure hydraulic system. In many instances direct acting hoists may be readily applied to hand-power cranes already in use, without in the least interfering with the gearing, and at a very small expense.

In an air-hoist the power and load are brought together in the most simple manner. A boy, with this aid, can lift a given load a dozen times while a gang of several men are operating a chain block or windlass. There is no noise, no jar, and the load is always balanced. In foundries where an overhead traveler cannot be installed, air hoists suspended from trolleys running on an overhead track answer very satisfactorily; and if hose couplings similar to those used in connection with the ordinary air brake are provided, by simply detaching the hose connection after load is raised, the hoist may be run on the overhead track to any desired part of the establishment.

This is especially valuable in conveying flasks outside of foundry to storage sheds, patterns to pattern shop, or finished castings to machine shop.

Nearly every foundryman is conversant with the value of air-hoists in the foundry for lifting flasks and copes, drawing patterns and conveying cores to ovens.

Few of us realize how cheap an air-hoist is to operate, apart from its convenience and speed in handling loads. It has been estimated by Mr. Frank Richards that at 100 lbs. gauge pressure compressed air costs 5 cents per 1,000 cubic ft. of free air.

In a very interesting article recently published, this gentleman figures the cost of operating a hoist as follows: "Suppose we have a hoisting cylinder 6 inches in diameter, with a piston rod or hoisting rod 1 inch in diameter and capable of lifting 4 feet or more. Then, using air in the cylinder at an effective pressure of 90 lbs., the lift of the hoist will be $(6^2-1^2) \times .7854 \times 90 = 2475$ lbs.

If this weight is lifted, say 4 feet, the volume of air used will be: $(6^2-1^2) \times .7854 \times 4 \div 144 = .7636$ cubic ft. To this we add 30 per cent. to cover all possible contingencies: $.7636 \times .229 = .9926$, and we will call this 1 cubic ft. The one loss that seems to be inevitable, and which is included in our 30 per cent. allowance, is in taking up the slack of the hoisting chain, or other means of attaching to the load, before the hoisting actually commences, so that a certain portion of the cylinder must be filled with the compressed air, besides the actual 4 feet of travel for the lift. As the air in the cylinder is up to a pressure of 90 lbs. or 7 atmospheres, the volume of free air used will be seven cubic ft., and the cost of this will therefore be 7/1000, or $.007 \times .05 = \$0.00035$, and this is all we have to pay for lifting more than a ton a height of 4 ft. A hundred of such hoists will be made, of course, for $0.035, or 3½ cents. The accompanying table, which might be greatly extended and still not cover all the actual conditions of service, will be found of interest especially in the idea that it conveys of the cost of air hoisting. It is probable that many persons will be surprised at the low figures.

In connection with the low cost of air, it is to be remembered that the hoists are also simple and cheap.

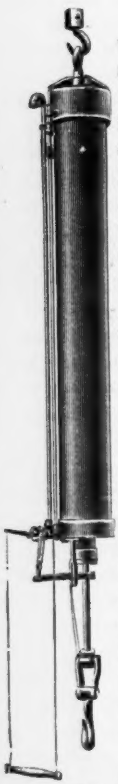
AIR HOIST TABLE.

A Table of the lifting capacities of direct acting air hoists, with volume of free air per lift, and cost of air per single lift and per 100 lifts, with a

maximum lift of 4 feet, and a minimum pressnre of 90 lbs. air furnished at 5 cents per 1,000 cubic feet of free air.

Diameter of Cylinder.	Effective Area of Piston.	Maximum W'ght Lifted	Cub. Ft. Free Air for 4 Ft. of Lift.	Cost of Air per Lift.	Cost of Air per 100 Lifts.
2	3.05	274	74	$0.000037	$0.0037
3	6.87	618	1.67	.000084	.0084
4	12.22	1099	2.97	.000149	.0149
5	19.09	1718	4.64	.000232	.0232
6	27.49	2474	6.68	.000334	.0334
7	37.42	3367	9.09	.000455	.0455
8	48.87	4398	11.88	.000594	.0594
9	61.85	5566	15.03	.000752	.0752
10	76.36	6872	18.56	.000928	.0928
11	92.39	8315	22.46	.001123	.1123
12	109.96	9896	26.73	.001337	.1337

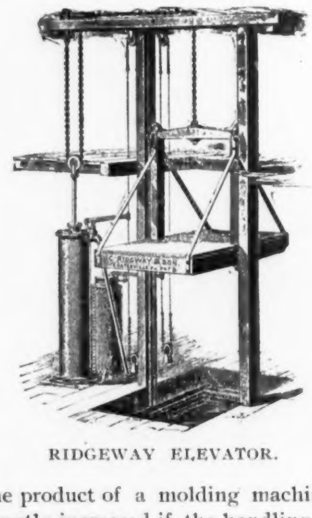
FRANK RICHARDS.



WHITING HOIST.

Air used in combination with a low pressure hydraulic system gives the best results for heavy loads. By interposing the water between the elastic medium air and the load, we eliminate that element of danger which otherwise would be present in handling vessels of molten metal, as in foundry practice, and also obtain a sort of elastic positiveness which is so essential and desirable. In the actual work of molding, as in lifting copes and molds, drawing patterns and moving cores, the men are enabled to do about 50 per cent. more work and do it easier and better, when equipped with a hydro-pneumatic hoist. Included in this percentage is the saving in repairs and the danger of losing castings. These hoists more nearly approach the old-fashioned hemp rope cranes in their elasticity, as the compressed air behind the water seems to impart this peculiar quality. All danger of the liquid freezing is overcome by using a non-congealing compound or a little glycerine, wood alcohol or chloride of magnesium added to the water.

In addition to operating movable hoists, air has proven its value for conveying pig iron to the top of the cupola, and for breaking up scrap by lifting a heavy weight which is dropped some 15 or 18 ft. This pig-breaker broke three half pigs into three pieces each in one minute, and can easily break twenty tons of pig while a man is breaking up one ton by the old sledge method. A portable pneumatic drilling machine for boring holes to weaken stiff castings is used to advantage in connection with this breaker.



RIDGEWAY ELEVATOR.

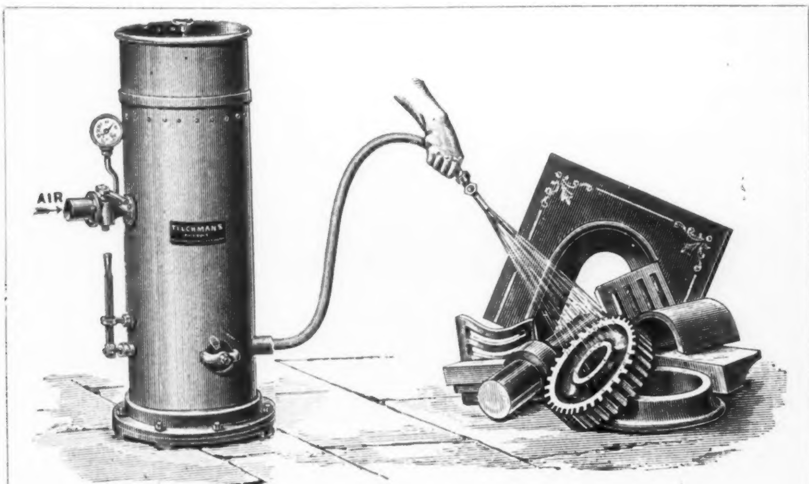
The product of a molding machine can be greatly increased if the handling of the sand in shovels is done away with. This is accomplished by an air jet which at 60 lbs. pressure will lift 100 lbs. of sand per minute 20 ft. high. A quarter-inch nozzle will use 90 cubic ft. of free air per minute doing this duty. By elevating the sand to a bin overhead and then conveying it in a chute or pipe directly over the molding machine, much time and labor can be saved.

A simple slide in the pipe forms a ready means of regulating the amount of sand served to the machine for each mold.

In a foundry where the air pipes have been led as previously indicated, and hose connections located at convenient points, the portable pneumatic sand-sifter is indispensable. In this machine a small amount of air operates a rotary motor which drives gearing connected to the sieve. Air admitted through an $\frac{1}{8}$ inch opening at a pressure of 70 lbs., developes sufficient power to do the heaviest work.

On rock drill steam chests, same machine, operated by two helpers, produces 66 molds per day. Formerly it required three molders to equal this number. In this case it would cost 125 per cent. more to turn out the same product by old method.

The economy of the sand blast for cleaning castings was quite as marked as that of the molding machine. On a flask 30″ x 14″ x 5″, made without using any facing, no difficulty was experienced in cleaning 6 sq. ft. of surface per-minute. A box bed plate, weighing 1,700 lbs., was cleaned in one hour by the blast, while another bed plate made from the same pattern, took three hours to clean by hand. With the blast the casting was cleaned so that the chipper did not have to do any cleaning as he had to do when blast was not used. Neither brushes nor files will get around fins and risers as the blast does.



WARD & NASH SAND BLAST CLEANING CASTINGS.

Recent observation of a molding machine in operation at the foundry of the Ingersoll-Sergeant Drill Company of Easton, Pa., gave the following figures:

On rock drill cylinders, three helpers operating a duplex machine can turn out 22 per day. It formerly took four molders to make this output.

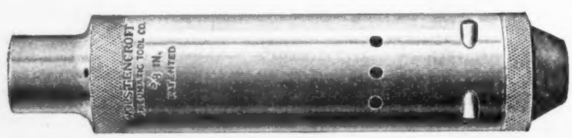
In other words, to do the work by hand now being turned out with the aid of the molding machine operated by compressed air, would cost 100 per cent. more than is being paid now.

A very difficult casting with cores that are almost impossible to get out by hand, was cleaned in 45 minutes by the blast, as against 2 hours and 40 minutes by hand.

In this same foundry they formerly melted about 5 tons of iron per day and employed 14 molders, 8 core makers, and a cleaning and chipping gang of 7.

They have practically doubled their plant and now pour 10 to 12 tons per day and employ 27 molders, 12 core makers and a number of labor-saving devices to increase their output, but the same cleaning gang of 7 men, with the addition of a sand blast, take care of the product, and the cleaning is done in a much better manner than previously.

The sand blast not only effects a great saving in the actual ccst of the castings, but a further saving through the removal of the oxide which is so destructive to tools in the machine shop.



WOLSTENCROFT PNEUMATIC CHIPPER.

This saving on tools is most apparent where the work is milled, as cutters can be run at an increased speed. The sand blast applied to the tumbling barrel is an improvement worthy of notice.

Aside from the economical features connected with the use of the sand blast, it cleans the castings far better than by hand, and where a casting has intricate steam or air passages it is of the greatest importance to be able to thoroughly clean these inaccessible parts.

Associated with the sand blast the pneumatic chipper shows to good advantage.

These tools were formerly too delicate and complicated for foundry uses, but recent improvements have so simplified their construction that they now have only three pieces in their entire make-up, and but one of these is a moving part.

Dark foundries have found the Wells, Lucigen, or some similar light of great use where a cheap intermittent light was needed. In these lamps compressed air forces oil through a nozzle forming a spray. which when ignited gives a flame about 5 inches in diameter and 30 inches long, and of about 1,000 candle power.

The air is used at a pressure of from 10 to 30 lbs., and one gallon of oil and 60 cubic ft. of free air per hour suffice to operate the lamp.

These hydro-carbon burners are very useful for skin-drying large molds as well as for lighting.

Breaking test bars from each cast is another use to which air has been applied.

A comparatively small air compressor of proper construction and design will furnish sufficient air for all the needs of a foundry of ordinary size.

An illustration in point is a foundry running 4 cranes of 20, 10, 8 and 1 ton capacity respectively; a sand blast, 2 pneumatic chippers, 1 duplex molding machine and for blowing out and dusting molds in process of construction.

In addition, the machine shop uses air for testing small engines and blowing out cylinder ports and inaccessible parts after machining, to get rid of oil and chips, and for bench dusting and copying letters in the office.

Air at 60 lbs. pressure for all these uses was supplied by a 14 x 16 x 18 compressor, running at 120 revolutions per minute and furnishing about 500 cubic feet of free air per minute.

Compressed Air as Used for Power Purposes.

A LECTURE DELIVERED BEFORE THE ENGINEERING SOCIETY OF COLUMBIA COLLEGE, ON APRIL 22D, 1896, BY FREDERICK C. WEBER, M. E.

(CONTINUED.)

The *second* loss is that due to clearance; the air in the clearance spaces in expanding back to atmospheric pressure prevents admission at the beginning of the stroke.

Fig. II shows a theoretical card (no clearance) from an air cylinder. The admission takes place at (A), follows along (A B); (A B G H) represents work of the atmosphere on piston in suction stroke. When the compression is isothermal, the compression line is represented by (B D) and by (B C) when compression is adiabatic. (C D E) represents receiver pressure. The temperature for adiabatic compression in this card is (450° F.) at the end of compression; and from C to E it is lowered, due to the cooling action of the

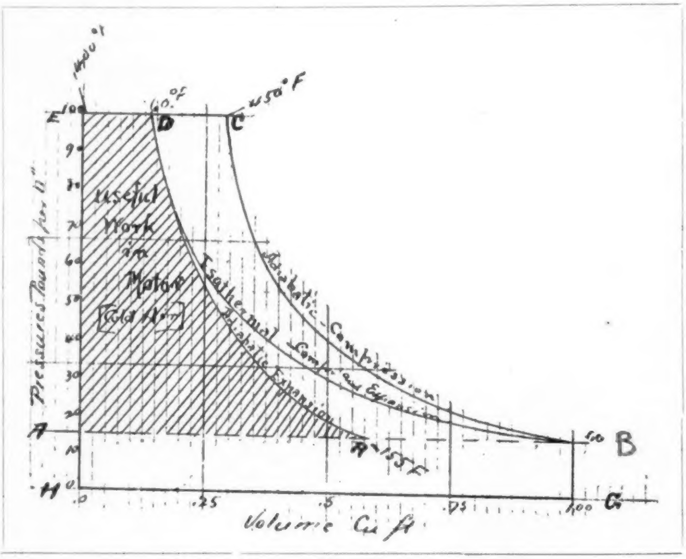


FIG 2.

The efficiency of the "intake volume" can be taken into account when a compressor is designed for a given quantity of air delivered, by increasing the diameter a fraction of an inch.

The *third.* loss involves friction of the mechanism, and has been reduced to less than 10 per cent. in the best compressors, and should not exceed 15 per cent.

The *fourth* loss is that due to the heat of compression, and is the most serious, and can be best shown by a diagram.

jacket water to about 400° F. From this diagram it is apparent that the benefit resulting from the jacket is greatest up to the point of communication between the receiver and cylinder (C); for after the terminal pressure has been reached there is no further need for cooling unless it be that the cooling for this part of the stroke (C E) helps to keep the cylinder cool for the next charge. If it were possible to obtain isothermal compression, the temperature throughout the process would be

60° F., and the area B C D would represent work saved.

In an actual diagram taken from a dry compressor, the line of compression lies very close to the adiabatic, because only a small part of the charge comes in direct contact with the cold walls; and since air has a very low specific heat and low conductivity, the cold does not penetrate the main body. When cards taken from a dry compressor show a compression line close to the isothermal, the chances of leakage by the piston or valves are very great.

stracting the heat during compression, for the jacket water of the simple compressor has been shown to abstract very little heat, the actual compression curve lying closer to the adiabatic than the isothermal.

This being the case, it clearly shows that the simple compressor is out of the question for high pressures when economy is looked for. The compound or stage compressor offers the best solution of this problem.

Fig. III represents a theoretical card taken from a compouud compressor. The

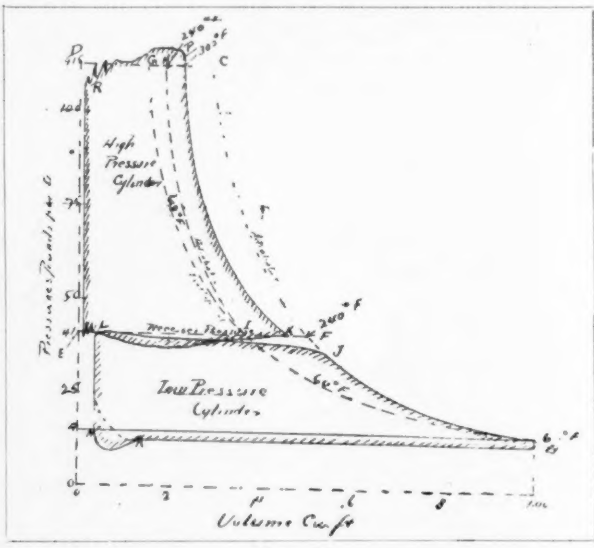


FIG. 3.

pressures are usually so proportioned that the total work is divided equally between the cylinders. Since any increase in temperature depends upon the ratio of pressures, the advantage of the compound compressors is apparent. The temperature now at the end of compression in each cylinder is 240° F. The pressure in the first cylinder is carried to 41 pounds (absolute,) and in the second cylinder the pressure reaches 115 pounds (absolute).

The line (L I F) represents the receiver

From the fundamental equation of a perfect gas we are able to deduce the following :

$$\frac{P_1}{P_2} = \frac{T_1}{T_2} \quad \text{(when volume remains constant.)} \; . \; . \; . \; . \; . \; . \; . \; . \; . \; \text{VI.}$$

Any increase in the ratio of pressures means a corresponding increase in temperature; and from what has just been said about heat losses, it is very evident that any increase in pressure will be followed by a decreased efficiency of the compressor unless some means are provided for ab-

pressure, or the intercooler. The air in passing from low pressure to the high pressure cylinder, passes through an intercooler and is cooled down from 240° to 60° before it is compressed a second time, or the shrinkage in volume is represented by I F. Compression in the high pressure cylinder begins at I, and for adiabatic compression follows along the line I H. Assuming, now, that the cylinder jackets

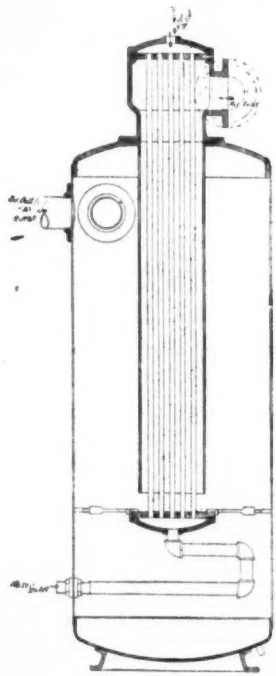


FIG. 4.

are inefficient, or that the compression process has been adiabatic in both cylinders, the saving due to the intercooler will be represented by the area F I H C.

INTERCOOLER.

The air in passing from the low pressure cylinder to the high pressure cylinder is conducted through an intercooler, which acts at the same time as a receiver.

This intercooler (Fig. IV. is filled with a number of small tubes made of material of high conductive capacity, through which water passes quite freely, and these tubes are so arranged that the air in entering the intercooler is made to flow over the tubes in fine layers, thus bringing as much of the whole body of air in contact with this cool surface as possible.

It is quite necessary that the intercooler should be of sufficient size to prevent fall in pressure when communication is established between it and the high pressure cylinder. Another advantage of size will be the greater chance of perfect cooling, shown on the card by a decrease in volume at the end of compression in the first cylinder and the beginning of compression in the second.

ACTUAL CARDS.

A set of cards taken from a compressor will show many defects, some of which have been shown in the diagram of Fig. III. For instance, if the admission is not free, the compressor will be working against a partial vacuum, following along M O instead of N B. Then, if the jacket is inefficient, the compression line will almost coincide with the adiabatic. Next, if the intercooler fails to cool the air to atmospheric pressure, the compression will begin at (K) instead of (I) in the high pressure cylinder.

The next loss is usually due to insufficient port opening at the discharge, or a loss in raising the delivery valve (P). If this valve is worked through a mechanical device from some other part of the compressor, a loss is often the result, due to late opening, the pressure in the cylinder being in excess of the receiver pressure, causing the air to expand from high pressure in cylinder to pressure in receiver, and no benefit is derived for the extra work done. Defective closing of discharge valves also causes a loss, as will be seen at (R). Clearance losses have been shown to affect capacity only; however, in the compound compressor this loss is reduced to a mini-

mum, for the air in the low pressure cylinder is at a lower tension, and consequently its expansion is not so great. The effect of clearance in the high pressure cylinder is to throw only a slight amount of extra work upon the low pressure cylinder.

If the intake valve does not open at the proper moment, a partial vacuum results, causing another loss, due to negative work, as seen at N M.

Fig. V. shows a cross-section of a double compound Norwalk compressor, with intercooler. There are 4 cylinders—2 air and 2 steam, arranged tandem—both pairs compounded. The cooling water is admitted first to the high pressure cylinder, then to the low pressure cylinder jacket, and lastly to the intercooler. The air is admitted to the cylinder by valves of the Corliss type, and have a positive movement from the main shaft.

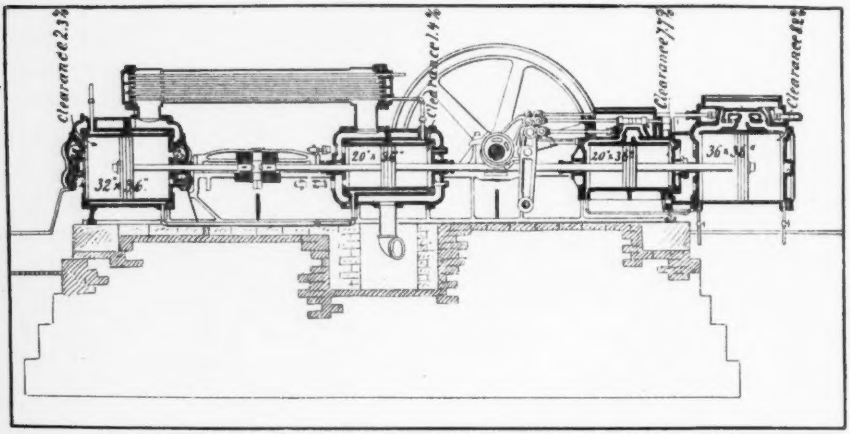


FIG. 5.

THREE AND FOUR STAGES.

The advantage of the compound compressor is very evident from Fig. III., showing clearly how near we approach the isothermal line. Theoretically we can achieve isothermal compression only if we had an infinite number of stages to compress to. However, the friction of the mechanism will soon put a limit upon the number of stages.

TABLE SHOWING PER CENT. OF WORK LOST.

I have prepared a table (Fig. VI.) showing the per cent. of work lost due to heat of compression, based upon Formula III., IV. and V. It is assumed that the temperature is brought back to atmospheric temperature between each stage, and no account is taken of the jacket cooling.

These figures speak for themselves, and show the advantage of compounding very clearly. For instance, at 2,000 pounds pressure, the loss in one stage compressor is 54.8 per cent.; in a two stage, 30.8 per cent.; and in a four stage compressor only 16.65 per cent.

COST OF COMPRESSING.

The cost of compression will be in direct proportion to the amount of work done—i. e., pressure and volume swept through,—and will depend upon the style of compressor. If a slide valve compressor is used to do the work, 30 or 40 pounds of steam may be counted upon to furnish a horse power; but if the compressor is a Corliss Compound Condensing Compressor, a horse power will be developed upon 15 to

FIG. VI.—PER CENT. OF WORK LOST DUE TO HEAT OF COMPRESSION.

Gauge Pressure.	ISOTHERMAL COMPRESSION AS BASE LINE.			
	One Stage.	Two Stage.	Three St'ge.	Four Stage
	No account taken of Jacket Cooling.			
	n = 1.408	Air assumed to be cooled to atmos temperature between stages.		
	Per cent.	Per cent.		Per cent.
60	23	11.8		4.45
80	25.26	13.12		4.80
100	27.58	14.62		7.41
200	34.40	18.88		8.27
400	40.75	22.90		11 04
600	44.6	24.60		13.10
800	47.4	26.33		14.32
1,000	49.2	28.10		14 45
1,200	51.6	28.60		14.85
1,400	52.0	29.4		15.00
1,600	53.3	30.0		15 54
1,800	54.0	30.6		16.05
2,000	54.8	30 8		16.65

18 pounds of steam, showing that for a permanent plant first cost is not the most important consideration.

COST OF HIGH PRESSURES.

The power cost of compressing to high pressures is not proportional to the pressure. It costs less proportionately to compress from 1,000 to 2,000 pounds than it does to compress from atmospheric pressure to 1,000 pounds. This can be shown by placing proper values in Equations IV. and V. Theoretically a point can be reached in the compression curve where a slight increase of power will result in an infinite pressure.

RAND FOUR STAGE COMPRESSOR.

The total compression is accomplished in four stages, and it is designed especially for marine service, to supply the torpedo boat with power for discharging torpedoes.

The problem for the designer was compactness consistent with strength and least weight.

[TO BE CONTINUED]

COMMUNICATIONS.

Some ten months ago we conceived the idea that a saving could be made in our plant of the air compressor. After completing cylinders and piston we removed one of the steam cylinders from the double engine and put on our compressor cylinder; there being a disc on each end of the engine shaft, the engine attached to one, and the compressor attached to the other. Upon testing this machine we were very agreeably surprised in being able to raise 160 lbs. air pressure with a boiler pressure of 90 lbs., and at M. E. P. of only about 75 lbs. to 80 lbs. This was something unusual to us, as the cylinders were of the same bore, and we had never heard of a compressor doing so before. Finding our compressor so satisfactory, we attached it to a receiver 48″ in diameter and 100″ high, from which we are to-day supplying twenty-two air hoists, ranging in capacity from 1,000 lbs. to 14,000 lbs. lift, and of a total capacity of 74,000 lbs. We also have a small sand blast which is supplied by the same compressor; this blast is used in cleaning castings. We have air applied to our foundry crane of four tons capacity, which gives the best of results, making it impossible to jar a core or drag in raising them, as the air lift is a cushion in itself. Another feature in its use is, when a ladle of melted iron is raised to the proper height for pouring, and the air shut off as the iron is poured out the ladle gets lighter; the air expands aud raises the ladle just fast enough for good pouring—in a sense making it automatic. In putting in air hoists our first idea was to put them in where our differential blocks were worn out; but, after getting one or two of them completed, and finding a great saving in the time and labor, we did not stop putting them in until every differential block had been replaced by them. We have no hesitancy in saying that there is a saving of from 40 per cent. to 50 per cent. in time in the use of our air hoists over the blocks.

BUSBY P. SWENEY, Sup't.
THE MARION STEAM SHOVEL CO.

COMPRESSED AIR.

(CONTINUED.)

Figure 3 is a graphic diagram drawn for the purpose of illustrating the fact that the power which is contained in any volume of air at a given pressure is dependent upon its distance in temperature above the absolute zero, and that there is as much power in a pound of air at fifteen pounds gauge pressure and 60 degrees temperature as there is in one pound of air at 100 pounds gauge pressure and 60 degrees temperature. One pound, or thirteen cubic feet of air at fifteen pounds pressure and 60 degrees temperature, is represented by the space C. The *available* power in this air is 21,469 foot pounds. By available power is meant the amount of power which can be utilized when this air is expanded adiabatically to atmospheric pressure. The diagram shows that when such pressure is reached the temperature will be—57 degrees Fahr. There sfill remains in this air a certain amount of *intrinsic* energy, and the diagram and figures show that this energy is equal to 74,134 foot pounds. This added to the available energy gives us 95,603 foot pounds, as the whole energy contained in one pound of air at fifteen pounds pressure and 60 degrees temperature.

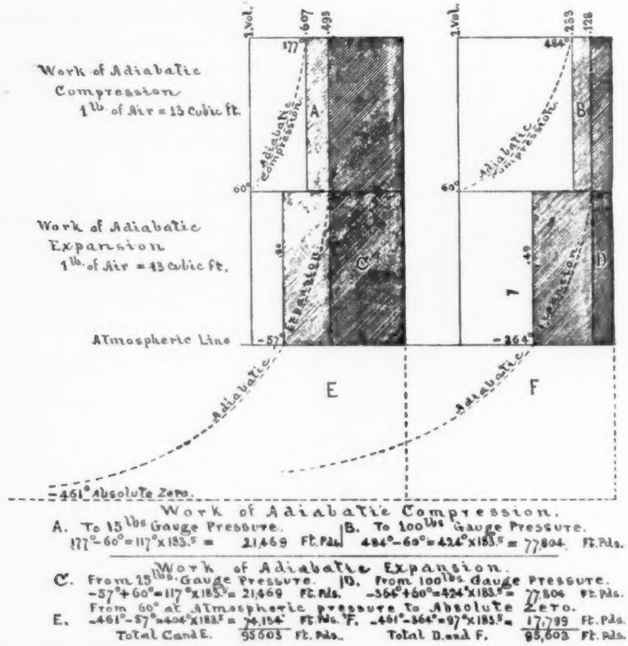


FIG. 3.

D represents one pound of air at 100 pounds pressure and 60 degrees temperature. Its available energy is 77,804 foot-pounds, and its intrinsic energy is 17,799 foot-pounds, or the total energy is 95,603 foot-pounds, which is exactly equal to the case just cited.

These figures show the correctness of that thermodynamic law, which states that the power of any elastic gas is in direct proportion to its height of fall. So long as the temperature is above the absolute zero; there is as much power in the same body of air when expanded adiabatically

from a moderate temperature to an extremely low one, as when expanded from a high temperature to a moderate one, and this offers to some extent a limitation to that system of reheating which increases the volume without at the same time increasing the pressure.

The development of heat when air is compressed is, perhaps, the best illustration of the acknowledged thermodynamic principle that work and heat are interchangeable unit for unit. When air is compressed all the work done in compression is converted into heat. This heat is capable of being converted back again into power. But the question is frequently asked, if it be true that the power applied in the steam cylinder of an air compressor is all converted into heat in the air cylinder, how is it that power still remains in the compressed air after the heat has been lost through transmission?

In order to get a clear understanding of this we must know that air is a power in itself before compression: that it contains a certain capacity for work due to its elasticity. It is not, however, in a condition *available* for work until compressed. This energy is made avalable by giving it a height of fall which is represented by a difference in pressure between the compressed air on one side and the free air on the other.

If we box up free air at any given temperature and under normal atmospheric conditions, we have within the enclosure a well defined amount of energy. We cannot use it to perform work unless the pressure outside is less than that inside the enclosure. This may be accomplished by placing the closed vessel in the rarified atmosphere, such as exists at altitudes, but in any case there is a well defined quantity of intrinsic energy within the air itself, the limit being measured by the height of fall between the free air in the vessel and absolute zero.

Compression as now practiced only serves the purpose of placing the natural power which we have in the air, into a condition which makes it possible for us to utilize it. This points to an undeveloped science in the use of compressed air. Inasmuch as we lose all the power expended in compression and yet have a capacity for useful work equal to from 30 to 50 per cent. of that power, it is plain that there are possibilities in the science which are now misunderstood and not realized.

W. L. SAUNDERS.

Tools for Stone Working.

The pneumatic tool used in stone cutting is one of great importance, and is likely to take precedence of every other device in shaping natural stone into whatever forms the architect or designer may specifiy. The skilled operator of this tool will do more work in a given time than ten ordinary cutters could in the old way. Its general use will bring about a larger demand for ornamental stone work in building and more monuments of better grade will be erected. The increased consumption will compensate for the reduction of the force of stone cutters, inasmuch as the output will need to be greater and the manufacture of the tools will employ large numbers of men. Such labor saving devices are not always the means of robbing the mechanic or artisan of employment, but rather broadens the field and increases their usefulness. The natural result is then that a less number of men are not employed but simply the transposition of talents from one activity to another, and mankind in general is the beneficiary.

Compressed air is the power utilized to operate this tool, and in skilled hands it marks out lines of beauty and symmetrical figures equal in finish to the clear cut work of the master in the art of chiselry.

With it the noblest conceptions of the sculptor are quickly wrought into enduring form.

Where power is available the cost of plants may easily be borne by even smaller yard owners.

WHAT THEY THINK OF "COMPRESSED AIR."

A monthly magazine called COMPRESSED AIR has been established in New York City, by W. L. Saunders, who, it appears is well qualified by experience and knowledge of compressed air matters, to produce a valuable publication. Three interesting numbers have been issued. The publica- has been heartily welcomed in industrial and transportation circles.—*Rome Sentinal, May 25, 1896.*

COMPRESSED AIR is the title of a new addition to technical literature. As its title indicates, it is devoted to the useful application of compressed air. It is in magazine form, is neatly printed and illustrated, and its matter is strictly pertinent to the object for which it is published. It is the first of its kind in the field and from its initial numbers is certainly worthy of that distinction. The editing and management of this serial is evidently in the right hands, and it has our best wishes for success. It has already received the special and unsolicited endorsement of practical men and with such a beginning to its journalistic career it can anticipate a bright future.—*Age of Steel, May 30, 1896.*

"COMPRESSED AIR" is the title of a neat little monthly publication edited and published by Mr. W. L. Saunders, 26 Cortlandt Street, New York. A copy of the first issue is before us, and we take pleasure in testifying to its interest and value.—*Colliery Engineer, May, 1896.*

THOSE interested in the subject will place their money to good advantage by subscribing for the paper as it is only one dollar per annum.—*Coal and Coke.*

THE increasing applications for this very desirable agent should certainly make a field for just such a paper.—*Editor Machinery.*

As a Mechanical Engineer and a member of the American Society of Mechanical Engineers I am of course interested scientifically in your most excellent paper, and in the subject of compressed air which has wrought so many changes in engineering in the last decade and probably ranks next to electricity in this respect.

FRANK CAZENOVE JONES, M. E.

YOUR Compressed periodical, Vol. 1, No. 2, which you sent me was interesting, and I believe will be of value to us in many ways. L. P. BRECKENRIDGE.

I HAVE already noticed with great interest the successive issues of "COMPRESSED AIR," and hope soon to be able to give you some interesting information.

JOS. H. HOADLEY.

The Whiting Foundry Equipment Co. have in their foundry at Chicago, a ten ton crane operated by compressed air, doing almost constant service, running night and day and doing very severe foundry work. It is working in a place where no other sort of crane would be available. It would be dangerous to put in electric motors on account of the heat and dust; and substantiates the claim of compressed air for superiority over all other methods for foundry purposes.

McNAB & HARLIN M'F'G CO.,

MANUFACTURERS OF

BRASS COCKS,

PLUMBERS' BRASS WORK,

Globe Valves, Gauge Cocks, Steam Whistles and Water Gauges,

WROUGHT IRON PIPE AND FITTINGS,

Plumbers' and Gas Fitters' Tools,

No. 56 JOHN STREET, - - NEW YORK.

Factory, Paterson, N. J.

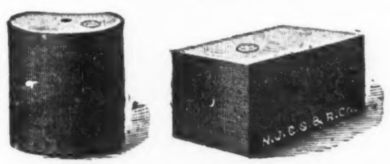
ESTABLISHED 1858.

"Our Name and Brand a Guarantee of Quality."

High Grade Rubber Goods.

CHANNELING SPRINGS.

BELTING.
TUBING.
VALVES.
HOSE
TUBING.



SPRINGS.
MATS.
MATTINGS.
GASKETS.
PLAY PIPES.

LINEN AND COTTON HOSE.

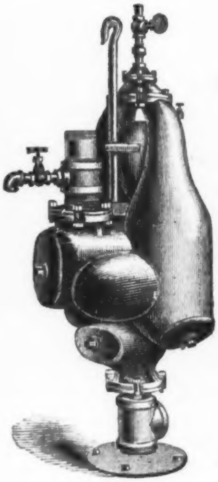
NEW JERSEY CAR SPRING & RUBBER COMPANY,

MAIN OFFICE AND WORKS:

Wayne and Brunswick Streets, Jersey City, N. J.

BRANCH OFFICE: 10 BARCLAY ST., NEW YORK.

THE PULSOMETER STEAM PUMP



"The Contractor's Friend."

OFTEN IMITATED—NEVER EQUALED.
OVER 20,000 IN USE.

Recent Important Improvements.

The Handiest, Simplest and Most Efficient Steam Pump for General Low Service Mining, Quarrying, Railroad, Irrigating, Drainage, Coal-washing, Tank-filling, Paper Mill, Sewer and Bridge Contractors' Purposes, etc., etc.

Muddy or gritty liquids handled without injury to the Pump.

PULSOMETER STEAM PUMP CO.

Catalogue on Application. **Correspondence Solicited.**

135 GREENWICH STREET, NEW YORK.

C. H. TUCKER, JR.

Contractor's and Machinist's

SUPPLIES,

SOLE AGENT FOR

Lightning and Green River Taps and Dies,

Bolt Cutting Machinery,

Eagle Sight Feed Lubricators,

Crane's Portable Drills.

135 GREENWICH STREET, NEW YORK.